

MPA Materials Matter

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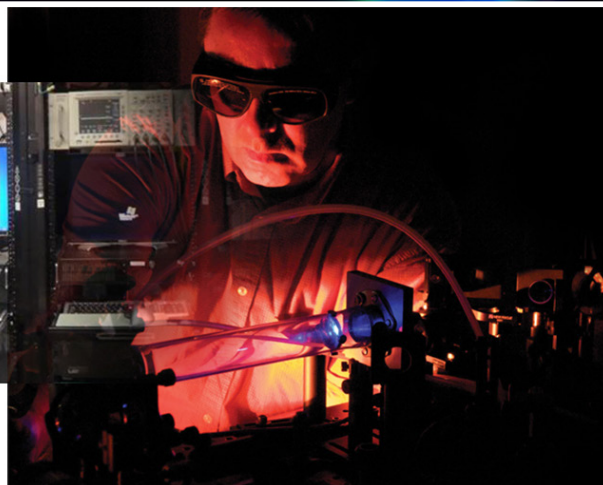
Heads UP!

Celebrating service



George Rodriguez, shown in the U1a underground lab at the Nevada National Security Site (left) and in a LUMOS laser lab (right), developed a fiber optic probe sensor for the Gemini project that has changed how Los Alamos does early-time hydrodynamic experiments. The sensor measures the changing energy flow in high explosives used in subcritical experiments.

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You find the opportunity space (at the Laboratory) is a lot bigger if you are willing to go out in other groups and divisions and make connections.
”



George Rodriguez

Getting big results from small-scale lasers

By Diana Del Mauro
ADEPS Communications

In a dark laser lab filled with shiny tabletop equipment, scientist George Rodriguez explained how he designs and builds small-scale instruments to probe the properties of everything from human DNA to subcritical nuclear explosions. During his 22-year career at Los Alamos National Laboratory, he has had countless successes, most related to fundamental materials science.

The story he tells today, however, is of applied research. Rodriguez is committing his signature creativity and ingenuity to one of the Laboratory's most pressing challenges—getting precise experimental data for the sake of refining codes used to predict nuclear weapons performance and longevity.

Rodriguez helped develop an advanced fiber optic probe sensor for studying materials in extremes by merging two existing technologies, pitched it to Physics Division, and found himself part of an 800-member team conducting subcritical weapons experiments at the Nevada National Security Site. For that work, he was honored with a 2014 Department of Energy Defense Program Award of Excellence as part of the Gemini Experimental Series team. For his leadership in the development and application of ultrafast laser-based and high-speed optical diagnostics for myriad applications over the course of his career, he was named a 2014 American Physical Society Fellow (For more on the award, please see page 5).

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Please consider attending the Materials Capability Review—it is a great way to learn about the Materials Capability at LANL.

”

Toni

From Toni's desk . . .

This column celebrates good news for MPA. Two of MPA-11 scientists, Piotr Zelenay and Jon Rau, were awarded Fellows' Prizes. Piotr was awarded the Fellows' Prize for Outstanding Research for leading the team that developed nonprecious transition metal electrocatalysts intended to replace platinum in polymer fuel cells, taking advantage of the latest developments in nanostructured materials engineering. Jon was awarded the Fellows' Prize for Leadership for his exemplary leadership in assembling and leading interdisciplinary teams of scientists to bring chemistry solutions and insight to bear on challenges in nuclear weapons, mentoring more than 25 young LANL staff members. MPA also has two new APS Fellows, George Rodriguez and Steve Doorn, both from MPA-CINT. George, nominated through the Topical Group on Instrumentation and Measurement Science, was selected as an APS Fellow “for his outstanding leadership in the development of ultrafast laser-based and high-speed optical instrumentation and his creative application of these diagnostics to the impactful measurement of materials, systems, and devices.” Steve, nominated through the APS Division of Laser Science, was selected as an APS Fellow “for his pioneering accomplishments in defining, shaping, and leading the field of spectroscopic characterization of carbon nanomaterials, including single-walled nanotubes and graphene.” I congratulate all of these award winners—you have made me, along with all of MPA, proud. Finally, I would like to thank those who worked on the nominations and encourage folks in MPA to nominate their colleagues for fellowships and awards, as appropriate. Although time-consuming, it is a very rewarding process.

Next, I would like to describe our upcoming Materials Capability Review that will take place May 4-6 in the JRO Collaboration Space (first floor of the Study Center). Dave Teter, who is leading the review this year, will present an overview talk on the Materials Pillar, while I will provide an update on the Materials Strategy. There will be an overview talk on LANL's Pu Strategy. Bill Priedhorsky will describe LANL's LDRD program and its relationship to the Materials Pillar. The Areas of Leadership that will be covered include Actinide and Correlated Electron Materials (led by Deniece Korzekwa and Mike Hundley) and Energetic Materials (led by Dave Funk, Jack Schlachter and Dan Hooks). There will be an overview talk presented by the theme leader, technical talks and posters in each of these areas, with a classified session included as well. Charlie Nakhleh, XTD division leader, will provide an overview of materials needs for the weapons program as the opening talk in the classified session. The National High Magnetic Field Laboratory—Pulsed Field Facility (NHMFL-PPF) will be the subject of a tour and an overview talk given by the NHMFL-PPF Director Chuck Mielke. Please consider attending the Materials Capability Review—it is a great way to learn about the Materials Capability at LANL.

Finally, I would like to announce the selection of Rick Martineau as MPA's new Deputy Division Leader. Rick has been working as acting MPA DDL since September and we are very pleased to have him continue in this role on a regular basis. Please provide Rick your full support. Take some time to let him know about your research and how he can help you.

MPA Division Leader Toni Taylor



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Since joining MPA-11 I have been truly impressed by the quality and breadth of the research performed in the Group and across the Division, and I am excited to be a part of this organization.

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From George's desk...

As the newest member of the MPA management team, I wanted to take this opportunity to introduce myself. I joined MPA-11 as a deputy group leader, along with my compatriot Jeff Willis, last October. Since joining MPA-11 I have been truly impressed by the quality and breadth of the research performed in the Group and across the Division, and I am excited to be a part of this organization.

By training, I am a chemical engineer and have spent most of my professional career in applied energy fields. I received my B.S. in chemical engineering from West Virginia University and then headed west for graduate school at The University of Texas at Austin where I received my PhD, also in chemical engineering. My graduate research was in the area of post-combustion CO₂ capture from flue gas, focusing on understanding the oxidative decomposition of alkanolamines and developing non-corrosive oxidation inhibitors to prevent this decomposition. This was a few years prior to the boom in carbon capture and sequestration funding, and after graduating I decided I wanted to learn about alternatives to fossil energy and nuclear energy seemed very interesting. I joined LANL as a Glenn T. Seaborg Postdoctoral Fellow in Chemistry Division working with Wolfgang Runde on developing alkaline separations for reprocessing used nuclear fuel. My research interests to this day continue to be understanding the fundamental thermodynamic and kinetic behavior of actinides and technetium in solution and solid-state and applying this knowledge to develop novel separations processes (most recently ionic liquids) and waste forms for the nuclear fuel cycle and actinide manufacturing processes.

Just prior to moving to MPA-11, I was the acting deputy group leader for C-IIAC (Isotope, Inorganic, and Actinide Chemistry) where I also served as team leader for the Actinide Chemistry Team at TA-48. Since 2009 I have served as the point of contact and coordinator for the Actinide Research Facility at TA-48, which hosts researchers from across multiple Laboratory directorates. I have spent nearly a decade working on projects funded through the DOE Office of Nuclear Energy, Fuel Cycle Technologies program. I currently serve as the LANL lead for the Materials Recovery and Waste Forms Development Campaign (formerly Separations and Waste Forms) working through the Lab's Civilian Nuclear Program Office. I truly enjoy the multidisciplinary nature of much of the work here at LANL and the opportunities this affords to bring together experts from seemingly unrelated fields to stimulate creative solutions to challenging technical problems. Along these lines, I hope to find additional opportunities to partner with the existing expertise in MPA to help develop new programs in the areas of actinide manufacturing and nuclear fuel cycles.

In closing I would like to thank Andrew, Jeff, Julie, Vanessa, and especially Brian Scott for getting me up to speed in my new group. It has been a pleasure getting to know some of the incredible people in MPA, and I hope to interact with many more of you over the coming months. My office is at TA-48, Building 208, Room 114 so please, if you would like to chat or come introduce yourself...my door is always open.

MPA-11 Deputy Group Leader George Goff

Rodriguez cont.

He is a member of the Center for Integrated Nanotechnologies' Laboratory for Ultrafast Materials and Optical Science (LUMOS) team, which uses ultrashort-pulse lasers and other instruments to gain material physics insights. LUMOS, which operates four laser labs at Technical Area-35, also custom-makes high-speed diagnostics for researchers.

Rodriguez devised an instrument that measures both velocity and pressure smack-dab in the middle of shocks and high explosive blasts. This fiber Bragg grating (FBG) sensor shoots light along a string of glass and bounces it off an optical grating-based sensor—a safer approach than conventional electrical switches, which require high voltage near explosives. The light source, FBG sensor, and sensor detection system fit on a rack the size of two dorm refrigerators and can be shipped to various locations. When the equipment travels to Nevada, so does Rodriguez, providing technical guidance during weeklong underground tests and interpreting results in a Laboratory report for the weapons programs.

"It's a neat technology," said Mike Furlanetto, head of diagnostics for the high-priority Gemini plutonium experiments. Instead of measuring only at specific times, the fiber optic probe continuously measures the high explosive burn from different locations in the device, capturing subtle changes in energy flow that the standard method could miss. "Having more elaborate data may help the Weapons Physics divi-

sions narrow down which parts of physics are deficient in plutonium performance models," he said, noting the sometimes vexing disconnect between experimental data and computer modeling results.

When not supporting experiments at the Nevada site or at the Los Alamos Dual Axis Hydrodynamic Radiographic Test Facility, where the sensor is being integrated into routine diagnostics for hydrodynamic tests, Rodriguez is developing the next version, which relies on ultrafast, short-pulse lasers to parse the effects of pressure and temperature from a single FBG sensor. Chemistry Division, as well as the weapons program, needs these readings for different applications that require measurements of materials in extreme conditions.

He also taps his laser expertise while drawing designs for the laser photoinjector of the MaRIE Injector Test Stand, part of the Matter-Radiation Interactions in Extremes (MaRIE) x-ray free electron laser. The FBG sensor is an example of the diagnostic development science of materials in extremes on the roadmap to MaRIE, the Laboratory's proposed experimental facility for time-dependent studies at the mesoscale.

Rodriguez, who earned his PhD from the University of Illinois at Urbana-Champaign, learned early to diversify. "You find the opportunity space (at the Laboratory) is a lot bigger if you are willing to go out in other groups and divisions and make connections," he said.

George Rodriguez's favorite experiment

What: Observe, for the first time, the effects of ultrashort pulse terahertz (THz) light radiation on cellular function

Why: To see if THz radiation has the ability to modify (enhance or suppress) DNA transcriptional activity at sites predicted by mathematical modeling to be sensitive to THz radiation. Transcription is the first step of gene expression in which the cell reads segments of its DNA that encode the information needed to produce needed proteins. Terahertz technologies are of growing interest for military, security, research, and medical applications, with potential medical use in cell therapeutics as applied to gene therapy.

When/Where: Various CINT User Program experiments since 2010

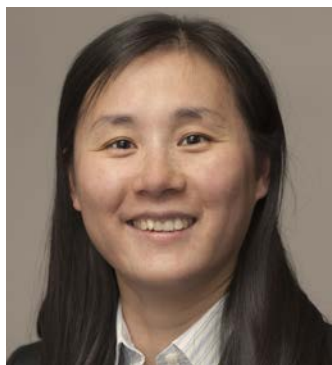
Who: Boian Alexandrov (Physics & Chemistry of Materials, T-1); Kim Rasmussen (Fluid Dynamics & Solid Mechanics, T-3); Alan Bishop (Science, Technology & Engineering, PADSTE); Charles Mielke (Condensed Matter & Magnet Science, MPA-CMMS); M. Lisa Phipps, Jennifer Martinez, Hou-Tong Chen, Steve Gilbertson, George Rodriguez (all MPA-CINT) collaborating with Harvard Medical School

How: Irradiated mouse stem cells for eight hours and looked for predicted changes in the transcription activity of DNA

The "a-ha moment:" We were all pleasantly surprised when CINT biochemist Jennifer Martinez came back to report microscopic images showing the morphology of these cells that had converted to fat cells in response to the radiation. The fact that our initial experiments precisely enhanced the mouse stem cell differentiation to fat (instead of other types of cells like muscle, bone, etc.), proved that we were successful at using THz to enhance those proteins at DNA transcription sites that control regulation into fat cells. Follow-up experiments confirmed our findings, and now THz studies and the effects on living cell function are being pursued by multiple groups as a possible route to control cell regulation. One of the most interesting aspects of the work has been the crosscut of technical expertise involved: math, biology, physics, and chemistry, a situation certainly made possible through the diversity of science at Los Alamos.

Ma recognized with Postdoctoral Distinguished Performance Award

Xuedan Ma, who holds a PhD in physical chemistry from the University of Hamburg, received a 2014 Los Alamos Postdoctoral Distinguished Performance Award for her “groundbreaking contributions to the study of solitary oxygen dopant states in carbon nanotubes” (CNTs). Nominated by Han Htoon and Steve Doorn, who mentored her from 2012-2015 at the Center for Integrated Nanotechnologies, she is now a postdoctoral researcher at Sandia National Laboratories.



CNTs are efficient conductors of heat exhibiting exceptional strength and electric properties. Recent studies have shown that new optical transitions can be introduced in carbon nanotubes through the incorporation of low-level oxygen covalent dopants on their side walls. Intentional incorporation of impurities and defects serves as a powerful tool for enabling of new materials functionality. The impact of her work spans from fundamental photophysics of CNTs to optoelectronic and quantum information processing technologies.

By performing the first low-temperature photoluminescence (PL) studies on individual oxygen-doped CNTs, Ma brought a deep level of understanding to the electronic structure and chemical nature of these dopant states. Furthermore, she discovered a new solid-state approach for controlled incorporation of these dopant states; one enabling states capable of emitting fluctuation-free PL emission over hours of continuous laser excitation, an improvement over conventional solution chemistry that exhibits PL fluctuation and bleaching. Exploiting these ultra-stable dopant states, Ma performed the first quantum optical experiments on the dopant states and demonstrated room temperature single-photon generation from them, previously considered impossible for one-dimensional carbon nanotubes. This discovery could spur a new branch of study in the area of solitary dopant quantum optics and reinvigorate efforts on development of CNT-based quantum light sources. These works led to three papers: one published in *ACS Nano*, another under review, and one submitted.

The Postdoctoral Distinguished Performance Award recognizes outstanding and unique contributions by Laboratory postdocs, which result in a positive and significant impact on the Lab's programmatic efforts or status in the scientific community.

Doorn, Rodriguez named 2014 APS Fellows

The American Physical Society recently elected Stephen Doorn and George Rodriguez (both Center for Integrated Nanotechnologies, MPA-CINT) as 2014 Fellows.

Doorn was nominated for “his pioneering accomplishments in defining, shaping, and leading the field of spectroscopic characterization of carbon nanomaterials, including single-walled nanotubes and graphene.” He was nominated by the APS Division of Laser Science.



Doorn earned a PhD in physical chemistry from Northwestern University, and joined the Lab in 1990 as a Director's Postdoctoral Fellow. He studies the spectroscopy and chemistry of carbon nanomaterials including carbon nanotubes and graphene. Doorn applies Raman spectroscopy for nanotube structural identification and characterization. He has discovered novel exciton- and electron-phonon coupling behaviors. Doorn uses photoluminescence spectroscopic probes of nanotube surface chemistry and surface structures to understand new optical behaviors introduced by dopant species. He is the Partner Science Leader for the Nanophotonics and Optical Nanomaterials research thrust of the Center for Integrated Nanotechnologies. Doorn has received a LANL Fellows' Prize for Research, DOE Office of Science Outstanding Mentor Award, *Nanotech Briefs* Nano50 Award for his role in development of ultralong carbon nanotubes, a LANL Distinguished Performance Award, and a Defense Programs Award of Excellence. He has more than 100 publications with more than 3,800 citations.

Rodriguez was nominated for “his outstanding leadership in the development of ultrafast laser-based and high-speed optical instrumentation and his creative application of these diagnostics to the impactful measurement of materials, systems, and devices.” He was nominated by the APS Topical Group on Instrument and Measurement Science.



Rodriguez earned a PhD in electrical engineering from the University of Illinois at Urbana-Champaign, and joined the Laboratory as a postdoctoral researcher in 1992. As part of the Laboratory for Ultrafast Materials and Optical Science team, he studies ultrafast optical science and develops

continued on next page

Fellows cont.

instrumentation with applications to spectroscopy, materials dynamics, and high-speed diagnostics. He is a member of the MaRIE (Matter-Radiation Interactions in Extremes) Accelerator Systems Board of Directors, providing laser expertise for the design of the proposed experimental facility for control of time-dependent material performance.

Using magnetic measurements to detect hydrogen contaminants in plutonium

Using magnetization, x-ray, and neutron diffraction measurements enabled by materials science capabilities at Los Alamos National Laboratory, scientists have demonstrated a technique for detecting low concentrations of plutonium hydride in samples.

The technique, published in the *Journal of Applied Physics*, is relevant to plutonium applications, workers who handle plutonium, and long-term plutonium storage. Contaminants, such as oxygen, hydrogen, and carbon, can degrade the mechanical properties of plutonium, causing consequences that can negatively affect health and safety.

Focusing on the effects of plutonium metal exposed to low levels of hydrogen during the radioactive decay process, Los Alamos researchers show that ferromagnetic remanence—the residual magnetization left in a ferromagnetic material (a permanent magnet) after exposure to a magnetic field—can detect small quantities of hydrogen against the background of pure plutonium. Pure plutonium is non-magnetic; however, researchers at LANL in the early 1960s discovered that the metal acquires a magnetic moment when it reacts with hydrogen to create plutonium hydride. Therefore, magnetic measurements can be used to detect the presence of hydride formation in plutonium metal.

Looking at samples of polycrystalline delta-plutonium stabilized with gallium, the researchers characterized the metallic crystal structures using the Neutron Powder Diffractometer and neutron diffraction at the Los Alamos Neutron Science Center, and found the samples to have the expected fcc structure and lattice parameters. In preparation for the magnetization measurements, the samples were exposed to hydrogen under partial vacuum at 450°C to ensure reproducible hydrogen solubility. One sample was loaded to a H/Pu atom ratio of 0.01 ± 0.0003 ; the second Pu sample was encapsulated without H loading.

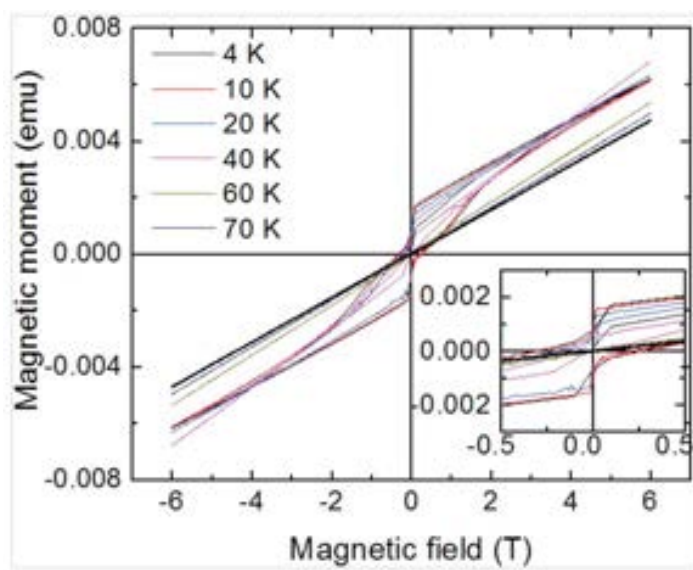
After sealing the samples in titanium containers in order to prevent radioactive contamination of the surroundings or exposure of the samples to air, the scientists measured the magnetization of the capsules as a function of magnetic field and temperature. They did so using a commercial vibrating sample magnetometer in a physical properties measure-

He received a 2014 DOE Defense Program Award of Excellence as part of the Gemini Experimental Series Team for successful subcritical tests at the Nevada National Security Site intended to get data on plutonium hydrodynamics as far into the implosion process as possible. He has 95 publications with more than 2,300 citations.

ment system at the National High Magnetic Field Laboratory-Pulsed Field Facility. The results confirm that the 2.0 at. % Ga stabilized H-free δ -Pu samples are non-magnetic between 4-300 K.

The outcome showed that commercial magnetization measurement techniques are sensitive to the conversion of tiny amounts (0.0015 mol fraction) of hydrogen in Ga stabilized δ -Pu to ferromagnetic PuH_x. This easily reproducible technique is a useful quantitative diagnostic to determine the content of small amounts of PuH_x in samples.

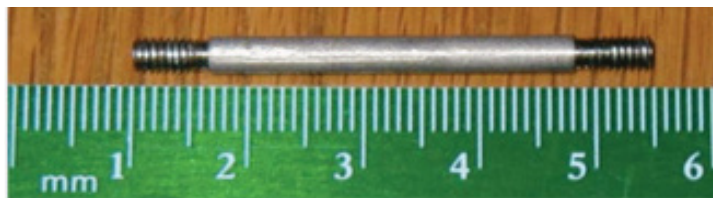
Work at LANL was supported by the Laboratory-Directed Research and Development program. Magnetization measurements were performed at the National High Magnetic Field Laboratory, funded by the U.S. National Science Foundation through Cooperative Grant No. DMR-1157490, the State of Florida, and the U.S. Department of Energy.



Magnetic moment as a function of magnetic field of δ -Pu with 1 at. % H exposure in Ti sample holder, minus the magnetization of the sample without H exposure in Ti sample holder. Measurements were conducted at. after zero-field cooling (in $H < 10^{-3}$ T) from room temperature and sweeping the magnetic field around a 6 T hysteresis loop starting from $H=0$. The inset shows a zoomed view of the magnetic hysteresis, with a linear background subtracted.

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Magnetic cont.



After sealing the plutonium samples in titanium containers, the scientists measured the magnetization of three capsules as a function of magnetic field and temperature at the National High Magnetic Field Laboratory at Los Alamos.

The neutron diffraction work was performed on the Neutron Powder Diffractometer at the Lujan Neutron Scattering Center, supported by DOE-Basic Energy Sciences under FWP No. 2012LANLE389.

Reference: "Detecting low concentrations of plutonium hydride with magnetization measurements," *J. Appl. Phys.* **117**, 053905 (2015), Jae Wook Kim (now at Rutgers Center for Emergent Materials, Rutgers University); Eundeok Mun (now at Simon Fraser University, Canada), Joe Baiardo, Vivien Zapf, Chuck Mielke (Condensed Matter and Magnet Science (MPA-CMMS)); Alice Smith, Scott Richmond, Jeremy Mitchell, Dan Schwartz (Nuclear Materials Science, MST-16).

Technical contacts: Dan Schwartz and Chuck Mielke

Novel crystal growth technique developed for high-efficiency perovskite solar cells

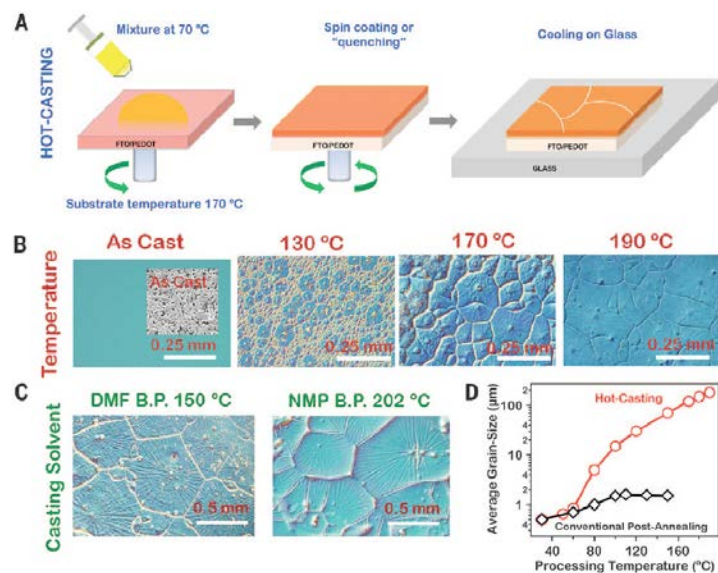
State-of-the-art photovoltaics—using high-purity, large-area, wafer-scale single-crystalline semiconductors grown by sophisticated, high temperature crystal-growth processes—offer promising routes for developing solar-based clean energy for the future. Solar cells composed of the recently discovered material organic-inorganic perovskites offer the efficiency of silicon, yet suffer from a variety of deficiencies limiting the commercial viability of perovskite photovoltaic technology. The deficiencies are instability, non-reproducibility, and hysteresis during device operation (possibly due to defect-assisted trapping). Los Alamos researchers and collaborators have developed a process to grow perovskite films that overcomes the technical challenges blocking commercial viability. The journal *Science* published their findings.

The team revealed a new solution-based hot-casting technique to grow continuous, pinhole-free thin films of organo-metallic perovskites that eliminates these limitations. The method enables the preparation of high-quality, large-area, millimeter-scale perovskite crystals and demonstrates that highly efficient and reproducible solar cells with reduced trap assisted recombination can be realized. The hot-casting technique enables the prolonged growth of the perovskite

crystal grain, yielding large crystalline grains. The team suggests that there are two primary benefits of growing crystals with large grain size: 1) The reduced interfacial area associated with large grains suppresses charge trapping and eliminates hysteresis, and 2) larger grains have lower bulk defects and higher mobility, allowing for the photogenerated carriers to propagate through the device without frequent encounters with defects and impurities. The crystalline quality of the perovskite films is comparable with that of high-quality silicon and gallium arsenide semiconductors.

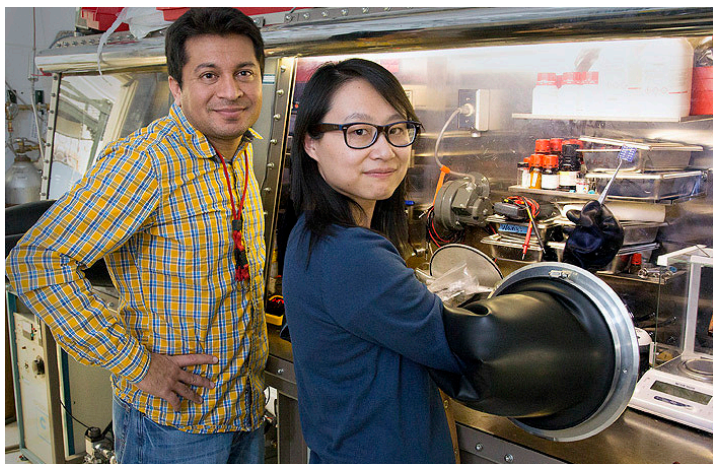
The researchers fabricated planar solar cells with efficiencies approaching 18%, among the highest reported in the field of perovskite-based light-to-energy conversion devices. The cells demonstrate little cell-to-cell variability, resulting in devices showing hysteresis-free photovoltaic response. Photovoltaic hysteresis had been a fundamental bottleneck for stable operation of previous perovskite devices. The team's characterization and modeling results attribute the improved performance to reduced bulk defects and improved charge carrier mobility in large-grain devices.

The method offers promising routes to develop low-cost, solar-based clean global energy solutions for the future. The benefit is a solution-processible technology that can form the active material for solar cells using a relatively



Processing scheme for perovskite thin film using hot-casting methods and observations for large-area millimeter-scale crystal grain formation for a perovskite ($\text{PbCH}_3\text{NH}_3\text{I}_{3-x}\text{Cl}_x$) based thin film. (A) Hot-casting scheme for large-area crystal growth [ITO, indium tin oxide; FTO, fluorine-doped tin oxide; PEDOT, poly(3,4-ethylenedioxythiophene) polystyrene sulfonate]. (B) Optical micrographs illustrating grain formation as a function of substrate temperature with the casting solution maintained at 70°C. (C) Large area grain formation using casting solvents with high boiling points (DMF, *N,N*-dimethylformamide; NMP, *N*-methyl-2-pyrrolidone). (D) Comparison of grain size as a function of processing temperature obtained for the hot-casting and conventional post-annealing methods.

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Scientists Aditya Mohite, left, and Wanyi Nie are perfecting a crystal production technique at Los Alamos National Laboratory to improve perovskite crystal production for solar cells.

low-temperature process (100–200°C). In contrast, silicon requires high temperature, expensive, sophisticated crystal growth techniques to produce the quality required to make efficient solar cells. The researchers anticipate that their solution-based crystal growth technique could lead to synthesis of wafer-scale crystalline perovskites necessary for the fabrication of high-efficiency solar cells. The method is applicable to several other material systems plagued by polydispersity, defects, and grain boundary recombination in solution-processed thin-films. The casting method is appropriate for both pure and mixed halide perovskite combinations and might lead to the production of industrially scalable large-area crystalline thin films made from other materials for solution-processed, large-area crystal growth.

Reference: “High-efficiency Solution-processed Perovskite Solar Cells with Millimeter-scale Grains,” *Science* **347**, 522 (2015). Authors include Wanyi Nie, Gautam Gupta, and Aditya D. Mohite (Materials Synthesis and Integrated Devices, MPA-11); Hsinhan Tsai, Jean-Christophe Blancon, Jared J. Crochet, and Hsing-Lin Wang (Physical Chemistry and Applied Spectroscopy, C-PCS); Amanda J. Neukirch and Sergei Tretiak (Physics and Chemistry of Materials, T-1); Reza Asadpour and Muhammad A. Alam (Purdue University); and Manish Chhowalla (Rutgers University).

The DOE Office of Basic Energy Sciences and a Laboratory Directed Research and Development project funded different aspects of the LANL work. This research was performed in part at the Center for Integrated Nanotechnologies, a DOE Office of Science User Facility. The work supports the Laboratory’s Energy Security mission area and Materials for the Future science pillar through the development of materials for high efficiency solar cells to generate electricity.

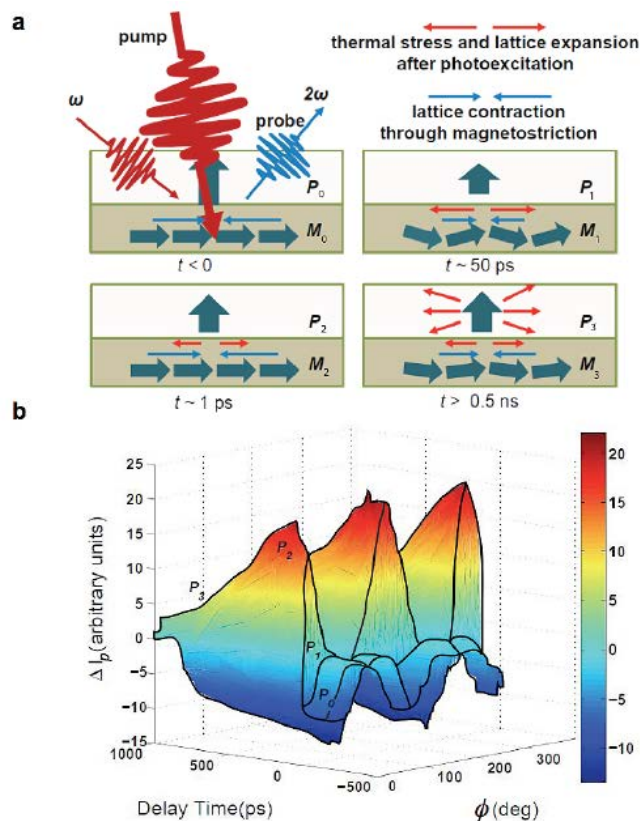
Technical contact: Aditya Mohite

Using ultrashort optical pulses to control magnetoelectric materials

Materials in which magnetic and electric order coexist have great potential for novel magnetoelectric devices, including applications in data storage, photovoltaics, and magnetic sensing. However, such materials are scarcely found in nature.

Researchers at the Center for Integrated Nanotechnologies (CINT) aim to unravel key microscopic mechanisms that could advance a more abundant alternative—the engineering of artificial multiferroic composites at useful temperatures. The team successfully demonstrated a new approach to detect and control the coupling between electric and magnetic order on ultrafast timescales. The work reveals the dynamic properties of multiferroics, a rarely explored aspect that affects their potential applications. *Nature Communications* published the findings.

The team used femtosecond optical pulses to explore and optically manipulate the coupling between ferroelectric (FE) and ferromagnetic (FM) order in an oxide heterostructure for the first time. They discovered that the timescale dominating the magnetoelectric response is governed by demagnetiza-



(a) Schematic diagram of the interplay between the lattice, the magnetization M , and the ferroelectric polarization P at different times. (b) Time-and-polarization dependent second harmonic generation signal, indicating the photoinduced changes in ferroelectric order.

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Ultrashort cont.

tion of the ferromagnetic layer through spin–lattice relaxation. Optically perturbing magnetic order in the ferromagnetic layer imposes lateral stress on the ferroelectric layer through magnetostriction, modifying ferroelectric order within tens of picoseconds.

This finding demonstrates that femtosecond optical pulses can provide insight into the microscopic mechanisms underlying magnetoelectric coupling in complex oxide heterostructures and to manipulate the magnetoelectric response in these systems on ultrafast timescales.

Reference: “Using Ultrashort Optical Pulses to Couple Ferroelectric and Ferromagnetic Order in an Oxide Heterostructure,” *Nature Communications* **5**, 5832 (2014). Authors include Yu-Miin Sheu (formerly with MPA-CINT), Stuart Trugman (Physics of Condensed Matter and Complex Systems, T-4), Li Yan (formerly with MPA-CINT), Quanxi Jia and Rohit Prasankumar (MPA-CINT), and Toni Taylor (Materials Physics and Applications, MPA-DO).

This work was performed at CINT, a DOE Office of Basic Energy Sciences user facility. The Laboratory’s Directed Research and Development (LDRD) program provided funding.

The work supports the Lab’s Energy security mission area and the Materials for the Future science pillar. Multiferroics have potential applications, such as reducing the energy required to switch hard drives in computers.

Technical contact: Rohit Prasankumar

Celebrating service

Congratulations to the following MPA Division employees celebrating service anniversaries recently:

Stephen Doorn, MPA-CINT	25 years
Jaroslav Majewski, MPA-CINT	20 years
Kevin Dudeck, MPA-11	10 years
Saurabh Singh, MPA-CINT	5 years

HeadsUP!

New access hours at TA-53 entrance

Access hours to the entrance gate of the Los Alamos Neutron Science Center (LANSCE) at TA-53 changed recently. The entrance gate (security post 416) is staffed by a SOC Los Alamos security officer from 7 a.m. to 3 p.m. For access to LANSCE before 7 a.m. or after 3 p.m., employees will have to swipe their badge through the Apollo reader in front of the gate.

Keeping it green

Late last year, the Laboratory’s recycling program expanded, accepting the same recyclable material as the Los Alamos County Eco Station. Your ADEPS EMS Team reminds everyone that the following items can be recycled in Laboratory recycle bins:

- #1-#7 plastic
- Aluminum foil and cans
- Paper bags
- Butter tubs
- Cereal and cracker boxes
- Hard- and soft-backed books and phone books
- Junk mail and magazines
- Milk and juice boxes
- Newspapers, office paper
- Plastic grocery bags
- Tin cans

In fiscal year 2014, the Laboratory recycled 92 % of construction and demolition waste and 55 % of nonhazardous office waste. With recycling bins open to more kinds of waste, this should be a banner year for diverting office waste from the landfill.

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Materials Physics and Applications

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